

### **Wednesday June,15,2016**

- Answer the questions that are the basis for the team contract.
- Team meeting time from 12:00 to 1:30 M,W,TH. Tuesday meeting with the instructors at the regular time 11:30 to 1.
- Problem: main idea still not clear, tasks for Thursday:
  1. Search and find articles.
  2. Visit and searching Company Solar Roads by Cour'dlean,ID or Sand Point,ID.
  3. Write contract and set up email for team email, also a whatsapp team chat.
- Plan for the tasks:
  1. Bader: write the team contract and setup team email and chat phone app.
  2. Yasser: search and get information about Company Solar Roads. Also, find 3 articles with small summaries about solar panels including material type, heating for snow, and basic idea.
  3. Hamzah: find 3 articles with small summaries about piezo electric and inverters.
  4. Yosef: find 3 articles with small summaries about piezo electric .

### Thursday June,16,2016

- Each of team members reads and sign the contract.
- Each represent their search and summeries:
  - a. Yasser:
    - Co. Solar Roads accept field trips and their website have very useful materials and very good demonstration about their solar system work.
    - A video about solar and piezo electric system by Scott Brusaw youtube.com channel.(The link included in the portfolio )
    - An Article about improving solar cells by using piezoelectricity and connecting them by nano wires to each solar cell.
  - b. Yosuf:
    - An article about another prototype of piezo electricity and it don't need a lot of movement.
    - An article about ecodrive which is a solar system accept any type of light.
  - c. Hamzah:
    - An Article about rectifiers used in piezoelectricity to convert from DC to DC to store the energy.
    - An article about harvesting energy by using a large capacitor.
  - d. Check next page for overall founds.
- Learning from Dr. Steve about a business class called the Vandal Pitch offered in the Fall.
- Put all the articles in the Portfolio.
- Tasks for Monday(June, 20):
  1. Each team members read the summaries and surf the Solar Roads website.
  2. Yosef will get a real solar cell to observe it in real. Also, Bader will get a real example of piezoelectricity to observe it in real.
  3. Each member read Project learning in mindworks websiteto help how to generate questions.
  4. Bader find articals about:
    - Self cleaning solar panels.
    - Energy storage.
  5. Each read their articals and generate Questions.

## **Monday, June,20,2016**

Morning after ME427 class:

- Meeting today at 4 PM
- Tasks for 4PM meeting:
  1. Everyone show up with their extra articles printed to include in the portfolio with their ideas.
  2. Generate 5 questions to ask Dr. Hess on Tuesday.

Afternoon Meeting at 4 PM:

- Discuss the 5 questions:
  1. Hamzah: 5 questions about converters and inverters.
  2. Yasser: 5 questions about solar cells and their details.
  3. Yosef: 5 questions about Piezoelectricity and connection with solar panels
  4. Bader: 5 questions about energy storage and solar services.
- See and visualize baders example of piezoelectricity: A lighter starter using a piezo method to produce a voltage at the end of the wire by pressing on the button.
- See and visualize Yosef's example of solar cell:
  1. Company name: Insta Park
  2. Model: Photovoltaic
  3. Type: SYS5S-M
  4. Max. Power: 5 Watts
- Each member email Hamzah the 5 questions so he can print them before the meeting.
- Discussing what are the main parts of the design:
  1. Solar panel with a controller and services.
  2. Piezoelectric generator and services.
  3. Energy storage and services.
  4. Power converters and inverters.
- Each member get ready for tomorrow's meeting.

**Friday June,24,2016**

- Discuss the problem statement.
- Discussing the system diagram:
  1. One charger controller take DC, where the piezo need a harvesting circuit to change from AC to DC and regulate the voltage.
  2. One controller (or two) to display information about power and piezo being used to wireless device. Also, Dr. Hamati has good idea about wireless communication (ask).

Questions to Dr. Hess with answers:

1. What is the best type of converter should be used to regulate the voltage?

DC/DC converter has a better charger:

- Find DC/DC converter that already done and developed it for this design.
- Has isolation (such as fly back) and up to 100 Watts .Also, we can use buck regulator (easy to control) by using many of them.
- Find DC/DC converters that have to deal with small frequency pulses. Also, if pulses move to the back would cause problems. Filtering would be an issue with DC/DC converters.

2.

- Reducing losses by using rectifiers switching in series.
- Using only two diodes for low voltage with the switches.
- Using full wave rectifier 4 diodes with high voltage.
- Or use MOSFET to reduce losses.

3.

- For piezo: search it since the power will act like a current source.
- Solar: find the max power where usually it's in the end at the corner of I vs. V graph.

4. Use many piezo 27mm and solar and put together and test them if they have high or low voltage.

5.

50-50 % power generation between piezo and solar. And combining them is the tricky part because they are different than each other.

6. SAME QUESTION 3.

7. For piezoelectric element try to connect it both in series and test it then in parallel then test it. After that compare the output to find out which one will give more voltage.

8. Depends if we test them and get closed voltage we add them in one controller also, by using DC-DC converter to regulate the voltage for both sources.

9.

- Lithium batteries less reliable, less safety has less weight. Has high power density.
- Used lead acid: more safety more reliable. Has less power density.
- New recharger batteries called lithium phosphate, it is very safe, but don't have that power density.

Extra discussion:

- We have to see the ratio of force and weight, what kind of patterns for the power generated by piezo, and movement deflection. (ASK M.E's)
- Meeting with on Tuesday and Friday at 1:30 PM.
- Tasks for Monday meetings (June 26):
  - a. Test the solar panel
  - b. Put the piezo electric together and Test it.
  - c. Combine both the piezo and the solar panel as one piece
  - d. Answer Dr. Steve questions for Tuesday meeting.

**Wednesday June 29, 2016**

- The group met with Dr. Beyerlein at 12:15 PM in GJ 108.
- Dr. Beyerlein helped the group to revise the problem statement to get more in depth details about our project.
- The following is the revised problem statement:

The purpose of this project is to establish the feasibility of a roadside hybrid energy collection/recovery system that can then be used for running nearby street utilities such as lights/signals. The hybrid sources are solar energy (harvested by a commercially available solar cell located next to roadway) and piezoelectric energy (harvested by an array of piezoelectric elements in the roadway). Each of these systems will have its own component level controller. A practical ratio of cost-effective energy recovery from these two sources will be sought in the design of the supervisor controller. It should be possible to monitor system performance via a wireless display located a safe distance from the energy harvesting equipment.

- Some specs have been identified during the meeting.
- **Solar specs:**
  - Direct current output.
  - Max output per panel (5watts/ft<sup>2</sup>).
  - Max operating voltage 20V.
  - Allows only unidirectional current flow out of panel.
  - Voltage and current regulation by component controller.
  - Output channel for instantaneous voltage & current.

- **Piezo Specs:**

- Up to 15 piezo devices.
- AC output that is rectified to DC.
- DC/DC conversion for compatible voltage with solar output.
- Output channel for instantaneous voltage & current.
- To be figured out:
  - Max weight applied?
  - Max displacement of piezo surface?

- **Energy Management Specs:**

- Can independently turn off solar and piezo device.
- LED to show when different energy sources are active.
- Communicates wirelessly with roadside display.
- 27mm brass outer diameter plate, 100mm leads.
- Resonant Frequency: 4.6KHz +/- 0.5KHz.
- Capacitance @ 100Hz: 16,000pF.

- **Group meeting**

- The group will meet tomorrow in GJ 108 at 1:00 PM.
- While we are in the lab, we will determine the following:

- Max weight applied on the piezo?
- Max displacement of piezo surface?

- **Individual tasks due before tomorrow's meeting.**

Yasser:

- Estimate energy produced by piezo.

Hamzah:

- Update the wikipage.
- Draw the system diagram by a drawing tool.

Bader:

- The basic functionality of the solar and the piezo.

Yousef:

- How much power is produced from our solar panel based on how much heat is transmitted.

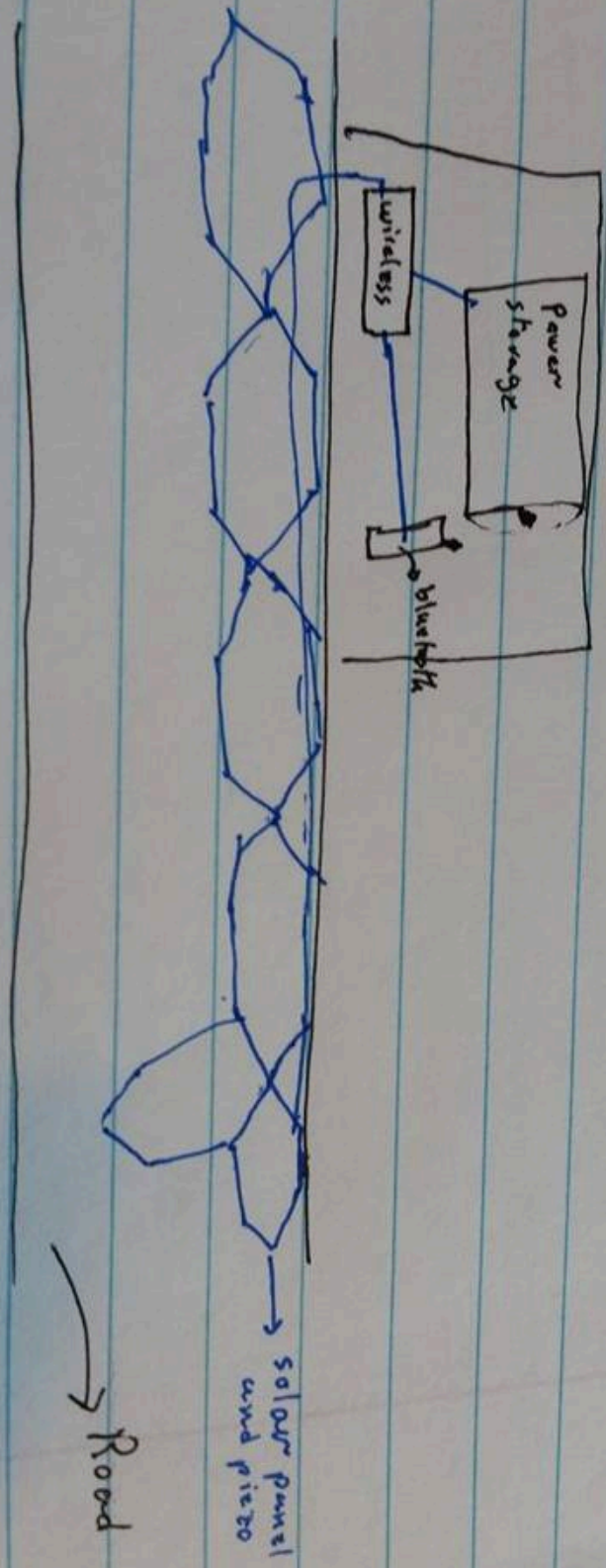


**Thursday June,30,2016**

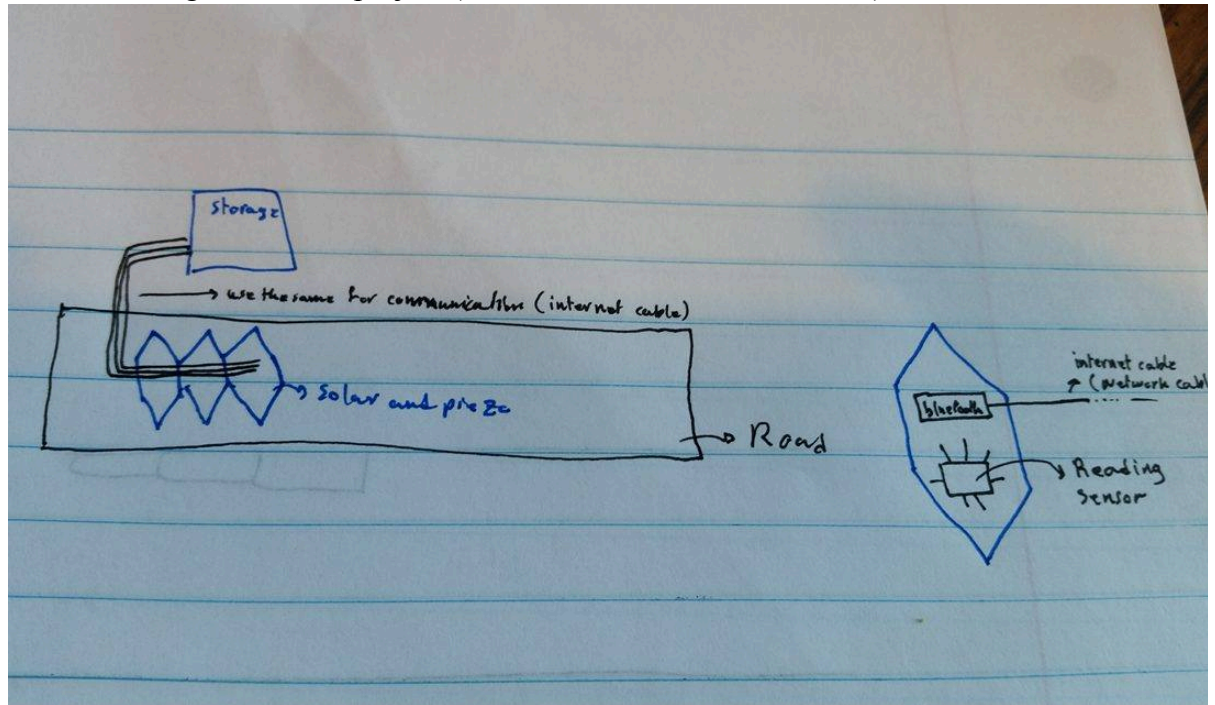
(Set of minute with Dr. Hamati and piezo testing)

At 1 PM meeting with Dr. Hamati to ask about the wireless device for communication:

- Discuss and explain our design.
- Discuss piezo effect. Each piezo give about 10-15 mW just an assumption, Dr. Hamati .
- Talk about Solarroadways company in Sandpoint, WA. They have the same idea and Sandpoint is a beautiful city to visit.
- Dr. Hamati Device:
  1. His design is more than detecting and reading power and voltages.
  2. The communication will be with the roads rather than using signal station.  
The communication will be by Bluetooth between the cars and the roads and the cars reads.
- Another idea: use a router connected by Bluetooth to send and receive and there will be a wire incase the Bluetooth got disconnected such as internet wire.
- Dr. Hamati telling us about a French company doing the same design and they are very advanced about it. They use special polyamories material instead of glass for the solar panels and it shows that it is more efficient.
- Our design idea for communication diagram:



- Dr. Hamati diagram for our project (each cell has a Bluetooth device):



- Dr. Hamati design for our project:
  1. It can read and communication by using Zig-BBee wireless device to do networking wireless and it is a one-piece device that needs a credit card computers to read information.
  2. Piezoelectricity: if we get couple of hundreds of them we would get few watts.
  3. There are another device like piezoelectricity that generate high voltage. But, we need moving parts inside it to increase efficiency
  4. Zig-bee (a passive device) is not expensive and they are for reading and they have sensors. Also, it has wires that can detect anything that is above it to show which piezo is being used.
  5. This design like the diagram is better for our design.
  6. Another idea, we can use one port per cell to show the voltage.
  7. Also, we need wires from the power stations back to the cells to melt the snow and detect piezo under use.
  8. Raspberry pie II is the recommended credit card size computer.
  9. Also, we may need to use Ni for measurement.
- Tasks and Agenda for Friday meeting after Dr. Hess meeting:
  1. Bader write the set of minute and agenda for both meetings on Thursday June,30.
  2. Yasser, write the agenda for Friday meetings with Dr. Hess and search Zig-Bee.

3. Yosef: Ni mesurment and get ready to be the manger and ask the questions with Dr. hess.
4. Hamzah: update wikipage and .

Meeting after Dr Hamati for piezo testing:

- Connect and test piezo parts.
- Connect 6 peizos in series:
  1. Press 2 piezo: 0.7-0.9 V
  2. Press 3 piezo: 1.9-1.9 V
  3. With connecting a full wave rectifier pressing 3 peizo: 0.6 V.
  4. With connecting a full wave rectifier pressing 4 piezo: 1.5 V.
- One piezo without pending it: 1.5-2.8 V
- One piezo with pending it: 1.6-3.6 V
- We have to change it to DC.
- 5 piezo all working together: 10-17 V and about 3 micro amp.
- Connect 2 piezo in parallel: 3.6V, 5.8 V
- Connect 3 piezo in parallel: 2.9 V, 1.9 V, 3.2V
- Connect 4 piezo in parallel: 1.6 V, 2.5V, 3.1V, 3.9V
- We need to use a circuit board
- Next meeting, we need to do more testing and find good measurement equipment.

## **Solar Road Energy Recovery (AGEs)**

**July 1, 2016**

### **Attendance:**

Everyone

### **Time:**

1:30-2:45 PM

### **Agenda:**

- Show the updated problem statement.
- Discuss the updated specs.
- Show the initial wikipage.
- Discuss the voltage values obtained from the piezo.
- Discuss our findings about the wireless device from Dr. Hemati's meeting and the group research.

### **Meeting Notes:**

- Dr. Hess noted that the problem statement does not say how the two systems work together and that need to be fixed.
- Dr. Hess asked us to include our system diagram with the problem statement.
- Dr. Hess would like to see an overall controller in our system diagram so that it controls the flow of energy from the storage, from the two sources and it also controls the communications.

- Every time we compress the piezo, we get different voltage values. Dr. Hess mentions that is expected to have different voltage values coming from the piezo. The reason for this is when we press it, we are making the voltage increase, and when we let it loose, it comes back down. So the energy given is in the pushing it up, there is a force times distance, that translates to voltage and if we have a load in the voltage, a current, so that will push the current into there, and when we let it back up, the voltage goes back down, we have what amounts to an AC (Alternating current). It is a very low frequency, and it is a frequency that is not going to be constant.
- One way to capture energy from piezo is adding a diode so that the current does not go back.
- Capacitive load is needed in series with a diode. The diode blocks the current to go back. The energy that way is stored and the voltage on the capacitor is brought up for each time the piezo is pressed.
- Small capacitor will have a higher voltage and vice versa.
- We have to place the piezo elements in a way that they can be bent a little bit so that most of the energy is obtained.
- Piezo elements are best placed in series because the current is the same and voltage is added.
- Dr. Hess would like to see a wireless device in our project to read measurements from the two systems. Dr. Hemati suggested three things to be considered to obtain a proper wireless device, zigbee, raspberry Pi 2 and national instrument measurement.

- Dr. Hess mentions that the Mechanical Engineering maintains a license for LabVIEW and we may want to talk to Dr. Beyerlein to find a technician to help us download the LabVIEW.
- We can get more details about Zigbee through Dr. Wall, Dr. Santora, or Dr. Cordon.
- Dr. Hess suggested some communication features to be displayed thorough wireless device (e.x. how much voltage and what the car traffic was, the status on output of the battery is).
- Dr. Hess required two pieces of status information on our piezo. That includes, voltage waveform, number of pulses it's done in a certain period of time and what the average voltage or energy out is.
- Dr. Hess required more specs with numbers.
- Dr. Hess wanted separate specs of communication based on what Dr. Hemati said.

**To do:**

- Fix the problem statement by mentioning how the two systems work together.
- Add an overall controller into our system diagram.
- Talk to Dr. Beyerlein about LabVIEW and how we can get access to it.
- Get in touch with the suggested contacts Dr. Hess mentioned to know more about zigbee.
- Specify more specs with numbers.
- Add communication specs.

**Next Client Meeting:**

Date: July 14, 2016

Time: 1:30 PM      Location: GJ 108

**Wednesday 7/6/2016**

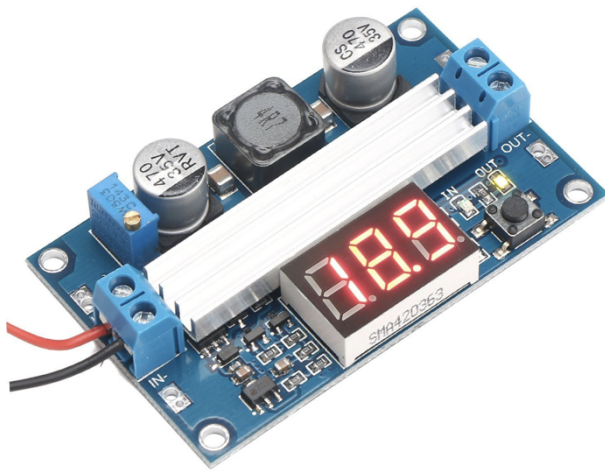
Time: 1pm-2pm

Agenda:

- \*Searching for voltage regulator and converter circuit.

- \* Purchasing dc/dc and ac/dc converter circuits.

- [DROK® Micro Electric DC/DC High Efficiency Boost Converter Step-up Voltage](#)



- Henglifu 2PCS IN4007 bridge rectifier AC to DC converter wave rectifier circuit board DIY





Thursday:

\*Testing

**Thursday 7/7/2016**

**Time:1 pm-3:30pm**

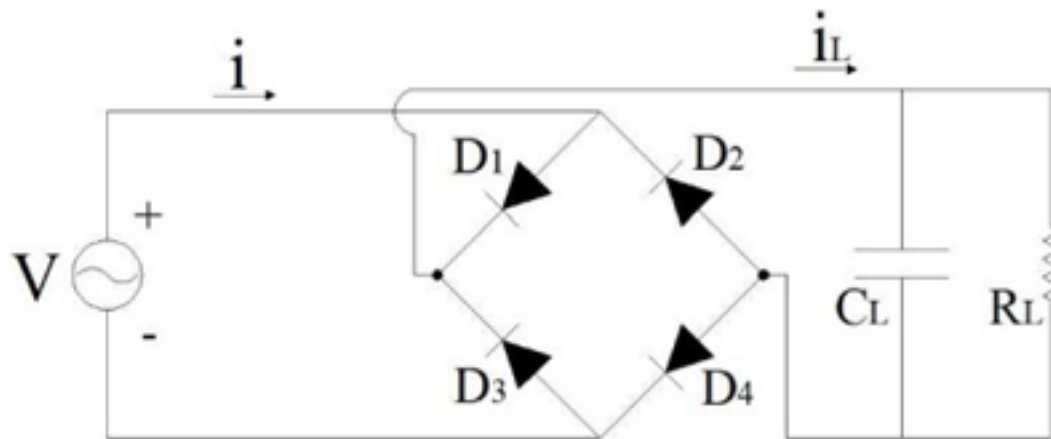
Agenda:

\* Testing

**Testing:**

\* Connecting five piezoelectric series with full wave rectifier.

\* Adding capacitor



**Figure 3. Schematic diagram of full-wave bridge rectifier.**

\* 220 $\mu$ F capacitor didn't work because it was too big.

\* Exchange it with 1 $\mu$ F, it worked pretty well:

Reading shows 1.6V for one capacitor.

Two capacitors= 2.3V

\* Attaching LED and capacitor in parallel and worked

Monday:

\* Wait for the harvesting circuit.

\* Test piezoelectric with the converters.

## **Solar Road Energy Recovery (AGEs)**

### **Set of Minutes**

#### **Date:**

Thursday 07/18/2016

#### **Attendance:**

All members

#### **Agenda:**

- Ask Dr. Hess if he might join our group's visit to Solar Roadways Company next week.
- Discuss the revised problem statement and see if it states properly how the two systems work together.
- Discuss our last testing of piezoelectric and how big capacitor did not work and small capacitor did.
- Discuss the questions written by Bader to the Solar Roadways Company
- Ask Dr. Hess if he suggests any more questions for Solar Roadways Company.
- Discuss the communication diagram drawn by Yousef.

## Meeting notes:

- Dr. Hess will join us in the trip to Sandpoint. Departure will be at noon Thursday 7/21/2016 and visit the company at 3:00 pm.
- Dr. Hess read the checked the problem statement after adding the communication and it looks good.
- Show Dr. Hess the DC-DC boost converter and he like the choice which can give better output in small scale.
- Discuss the piezo test result and Dr. Hess recommend to use only one diode to make the current flow in one direction and to reduce the voltage losses then the voltage will be hold in a capacitor then move to the DC-DC converter.
- Find a way to put more pressure in the piezo to have more testing procedure. We should talk to Mechanical Engineering department they might have some ideas in how to put energy in the piezo and what kind of equipment might do best to give the more energy with less work. Ask Dr. Steven if he has a good idea.
- Make a test for a piezo and find how much energy can get from it in the same pressure. Then, calculate the energy and get the average to find the capacitance to use to store the energy. Then, calculate the voltage needs to make the converter works well. Using  $\frac{1}{2}CV^2$ .
- The rectifier diode takes 1.2V to 1.4V other option is to use a germanium diode which has low voltage or schottky diode or Mosfet which has less voltage while conducting. The lower voltage across the Mosfet will give more voltage to the capacitor.
- Questions for Solar Roadways Company need to add more details.
- Ask the company about the sensing for the light to turn on or off.
- Ask them about the maintenance plan in the time intervals and how to clean them.
- Ask if they have wireless communication and what kind? If not what do you use?

- Find the average power they get per day and how to store it?
- Ask about the harvesting circuit and what kind of charger do they use?
- How do they test their product and get the result and the life time?
- How do they recycle it or get rid of it?
- We should send the question to the company ahead of time to give them an idea about our visit and they can be prepared.
- Dr. Hess checked the diagram for wireless device and how it will work to output the voltage.
- We should do some research about how digital voltmeter work and read about it to solve our issues. Then measure the voltage and connect it to the wireless device. In the other side use a receiver and a decode to display the result.
- **To do:**
- Add more questions and details to Solar Roadways Company.
- Work in the project review which due 7/29/2016.
- Define the problem.
- How to solve it with explanation. Using diagrams, data sheets, pictures from trip, and more details. Make a complete circuit for the problem and how it will work.
- What we are going to do to prove the problem

#### **Next Client Meeting:**

Date: Monday July 25, 2016

Time: 1:30 PM

Location: GJ 108

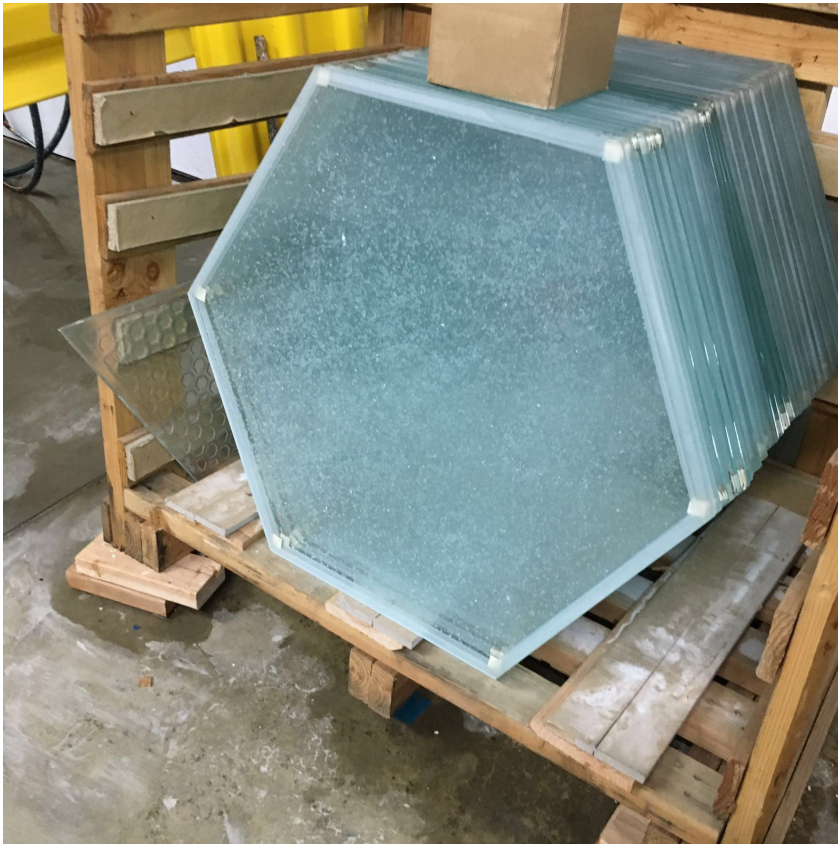
## Solar Roadways Trip

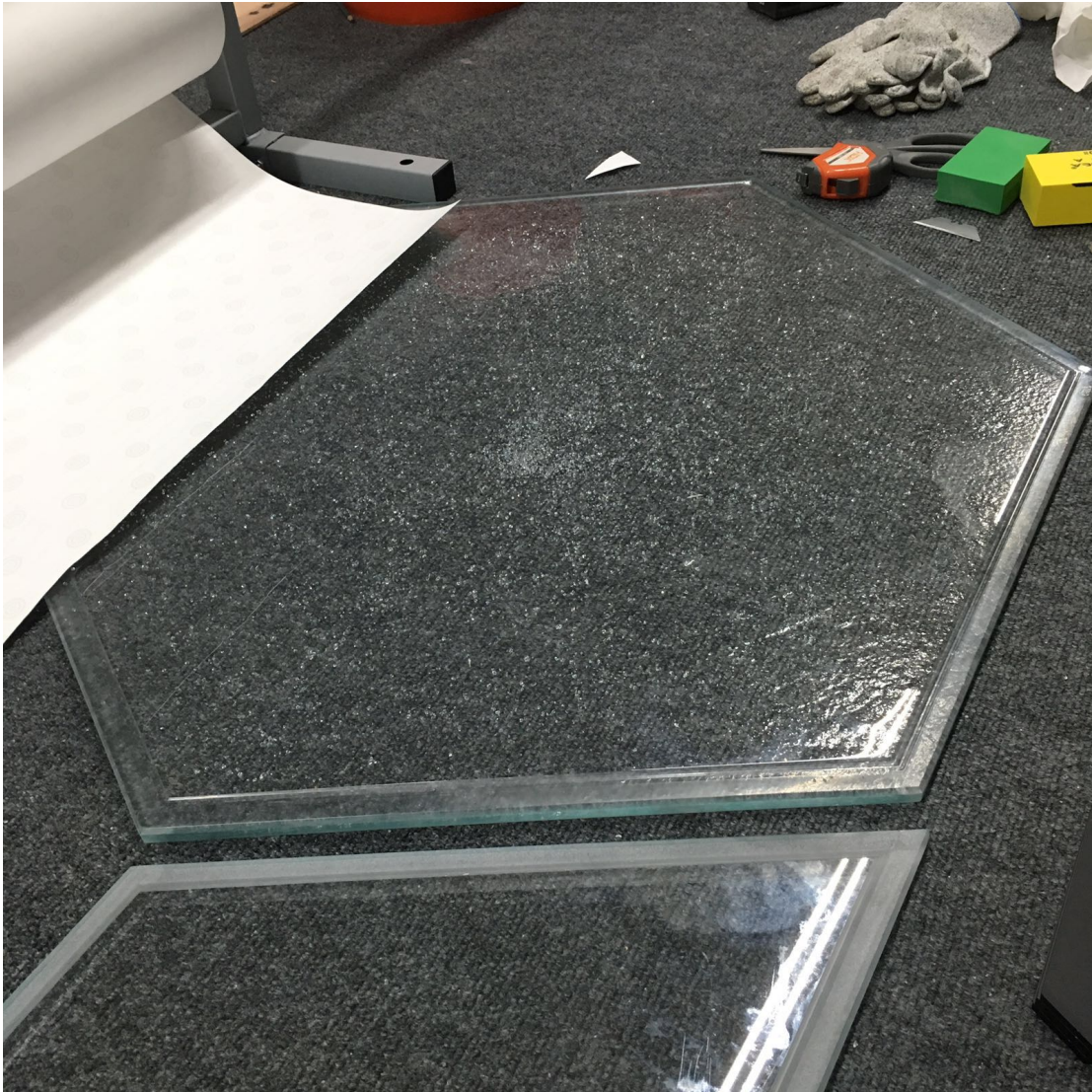
Time:3:00-4:30

7/21/2016

Alyssa mentioned:

- They use hexagonal glass shape to distribute the load.



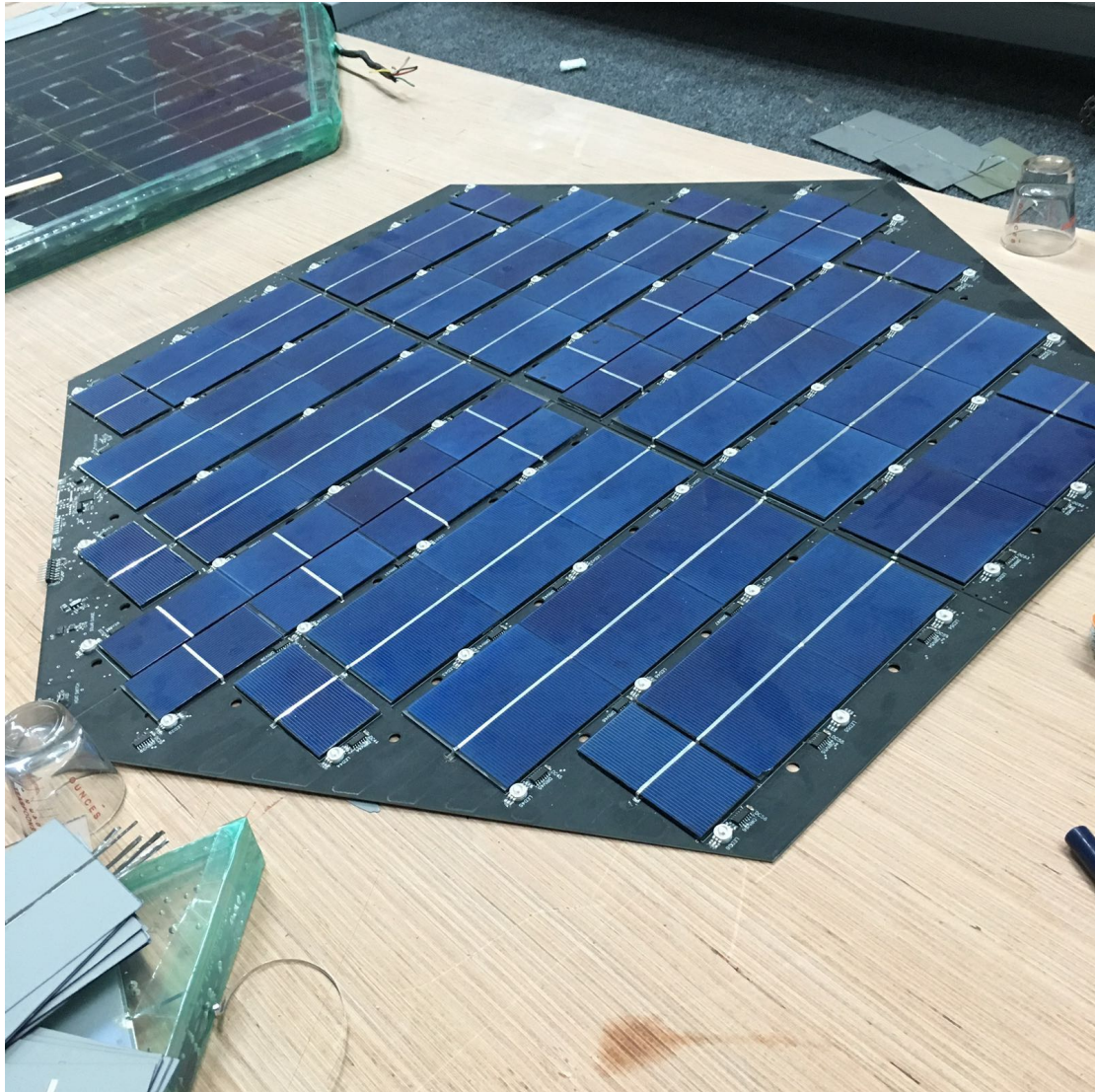


1- Testing the strength of glass by shooting 22mm bullet, the bullets did not make it through the glass.

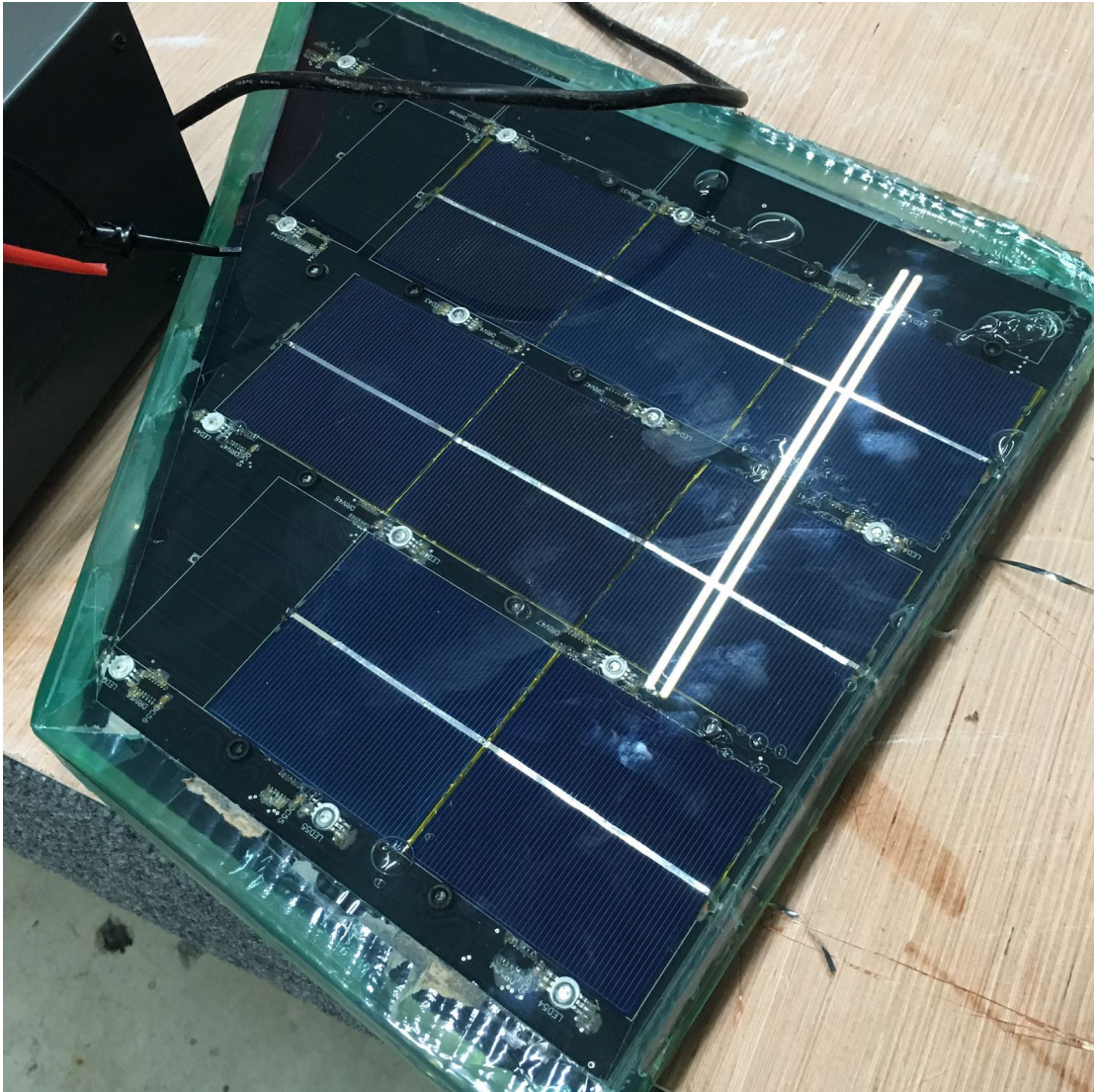
2- some glass design has small channels that water can go through and keep the surface dryable.

Alyssa answered the AGE team about the recycling components, Solar Roadway looks for some companies are able to recycle their materials such as glass and solar cells.



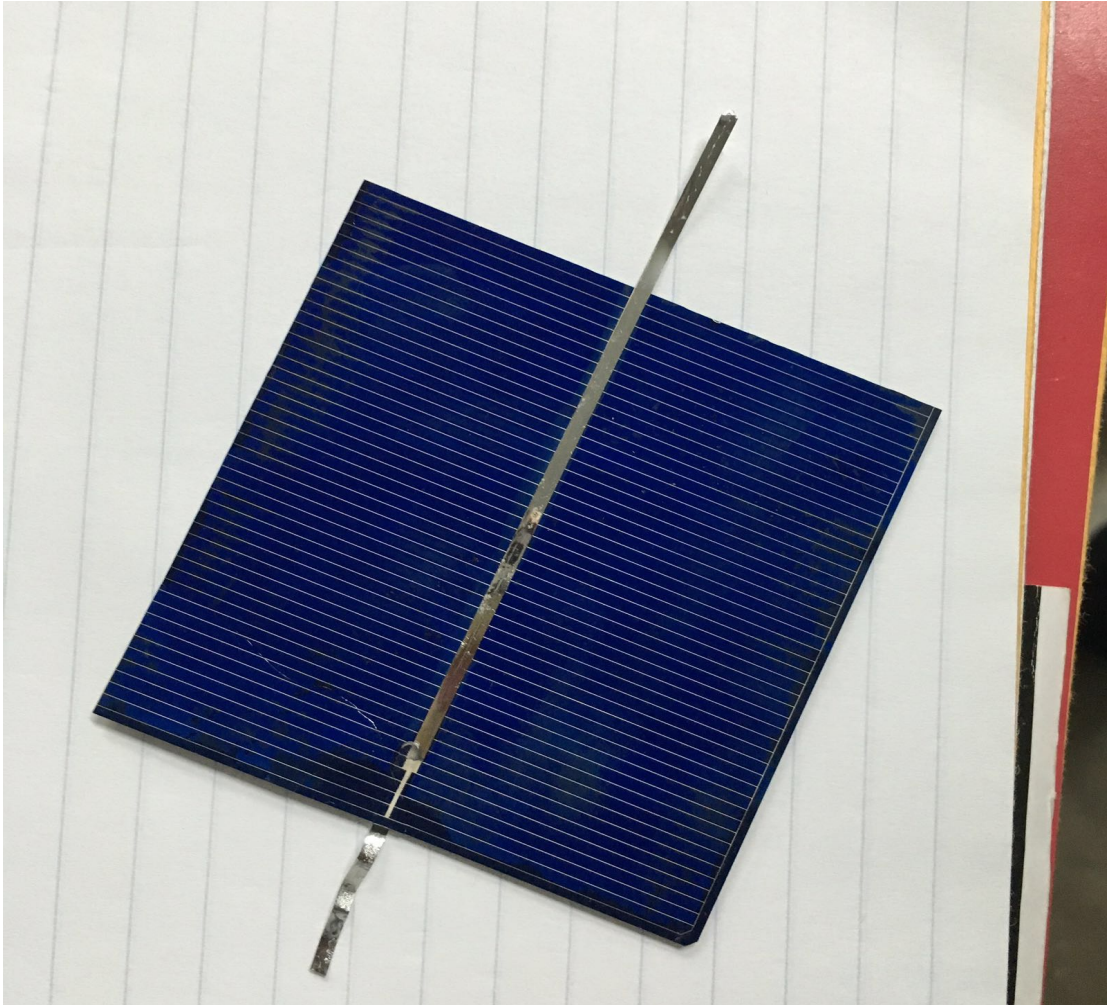






- Each panel is made from 4 small panels attached together to get better efficiency.
- The company preferred to use the heating system where it is controlled by computer and it set it up at specific temperature level to keep the circuit functional.
- She mentioned that LED has different color combinations, it has blue, green, and red where they light up in different combination to get a new light color.
- Each panel communicates with 6 panels wirelessly and reports back to the computer to detect failed panel.
- Protecting the panel by covering it titanium dioxide and that makes washing the surface easily.

- Store the energy from the panel to the directly then the heat system and LED use the power from the grid.
- Using Polycrystal is easier monocrystal to deal with, easy to apply it on the circuit and cover it by glass.



- The AGE team suggested to Solar Roadway to add the piezoelectric, The Company found that piezoelectric is not efficient energy source.
- Also the AGE team suggested to the company to use solar thermal to increase the energy.

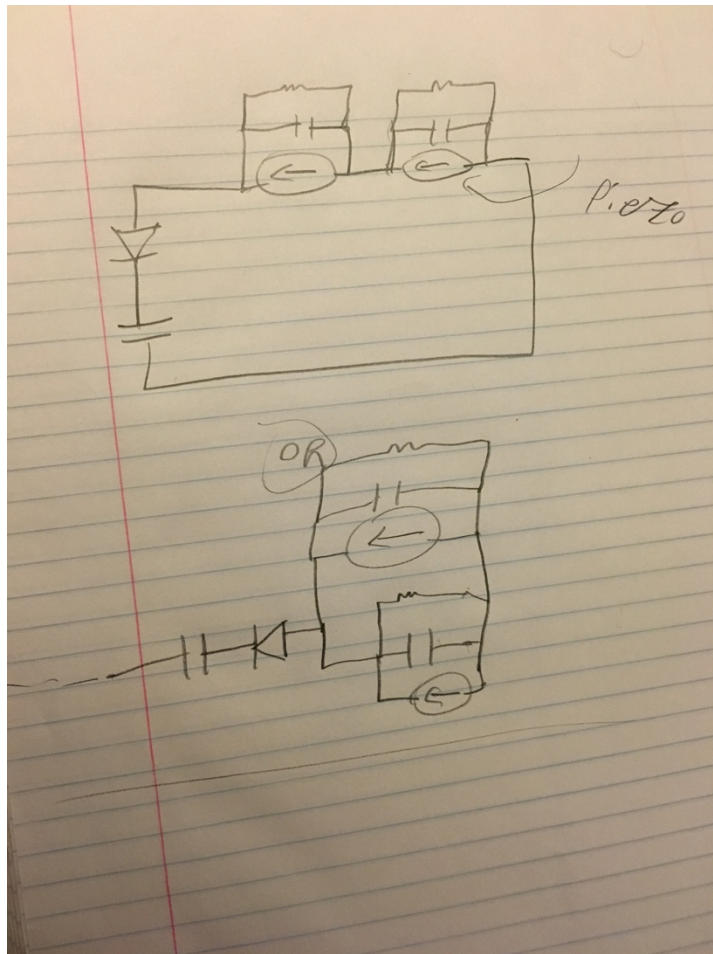
7/25/2016

## Set of Minutes

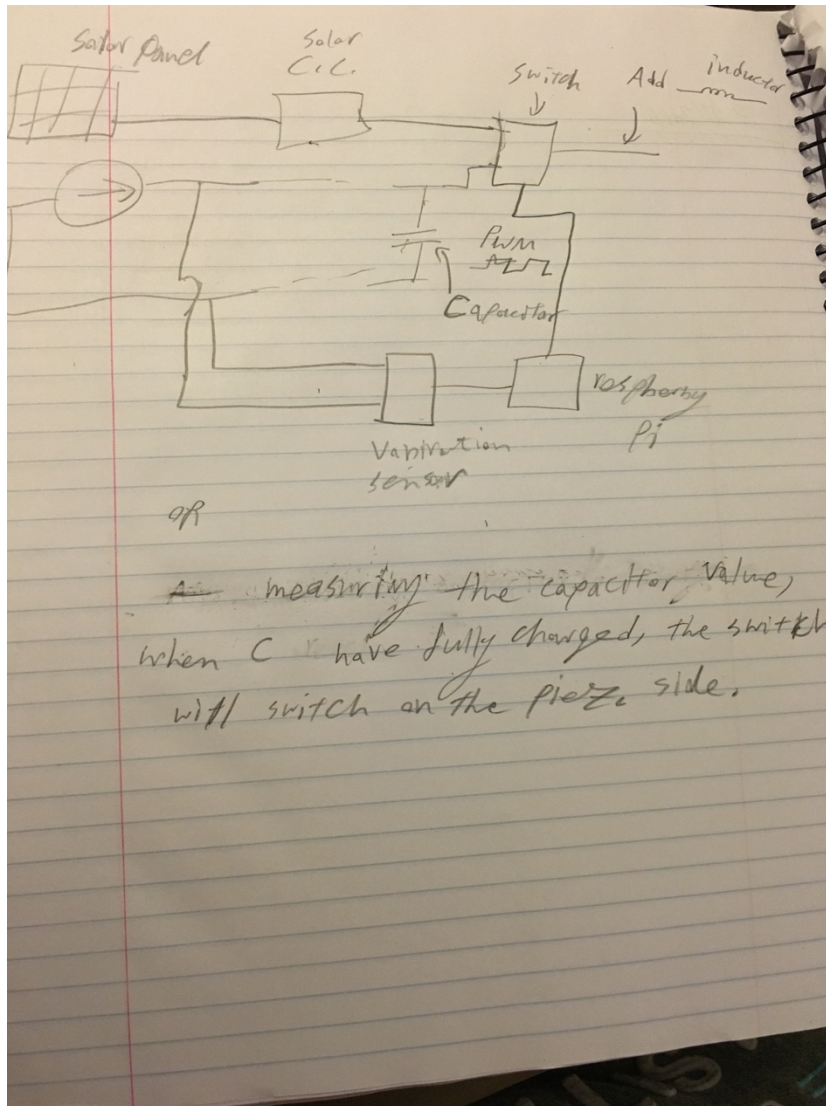
Time:1:30-4:45

- Hamza mentioned the issue with piezoelectric connections to Dr. Hess, adding 3 piezoelectric in series or parallel give less voltage than one piezoelectric.
- Dr. Hess asked the team to check the voltage for each piezoelectric at the same time on the oscilloscope has different channels.
- Dr. Hess mentioned to take 2,4,6 samples and get the average voltage and maximum voltage.
- Yousef suggested defining the wave reference from the oscilloscope, defending Sin or Cos Fourier series wave to define the samples.
- Dr. Hess asked the team to use wave length transformation method to analyses the piezoelectric voltage wave.
- Yasser showed Dr. Hess the calculation for the capacitor by calculating the deflection then calculate the energy.
- Hamza and Bader showed Dr. Hess the capacitor behavior where it drops slowly.





- Dr. Hess suggested adding resistor and capacitor with the piezoelectric in parallel to let the current goes through when one of the piezoelectric is not pressed yet.  
Note: in series connections, if one of the piezoelectric is not pressed, it will generate huge energy losses.  
- Or truing to adding them in parallel to increase the current and constant voltage.
- Yousef suggested adding BJT instead of diode to reduce the energy losses.
- Defining the resistance by  $R=t/C$  where  $C=5\mu\text{F}$  and  $t= 10 \text{ sec}$ , then  $R=2*10^6 \Omega$ .



For communication part:

- Yousef and Dr. Hess discussed about applying buck-boost converter theory after converting from AC to DC.
  - Attaching vibration sensor to the capacitor that is shown above, when the capacitor got fully charge, the switch goes to piezoelectric circuit then discharge the capacitor.
  - The switching time is matter because it supposes to switch on the specific time.
- The team decides to use LT Spice to simulate the circuit.